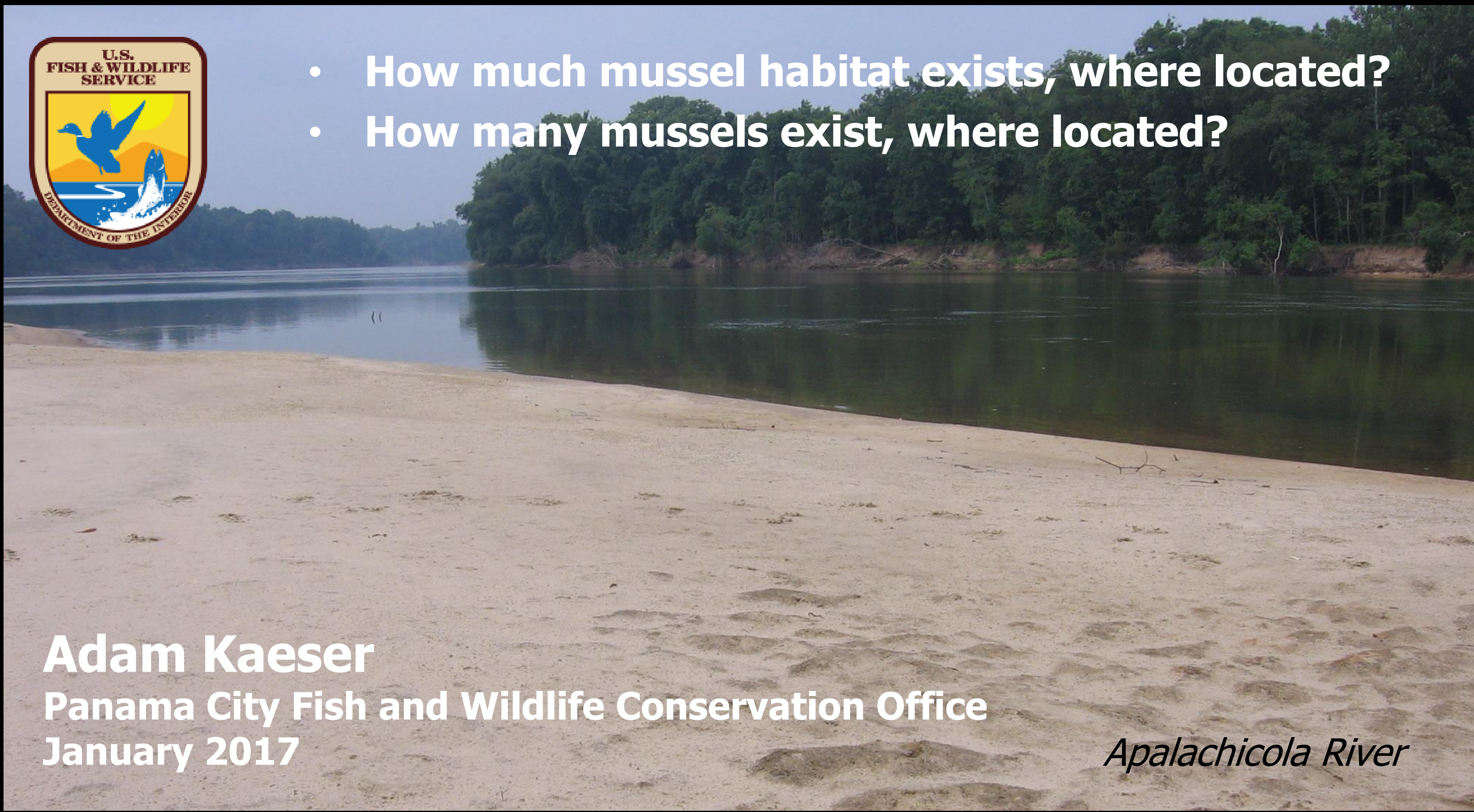
Mapping the distribution and abundance of mussels and suitable habitat throughout the lower ACF



Initial Focus - Middle Apalachicola

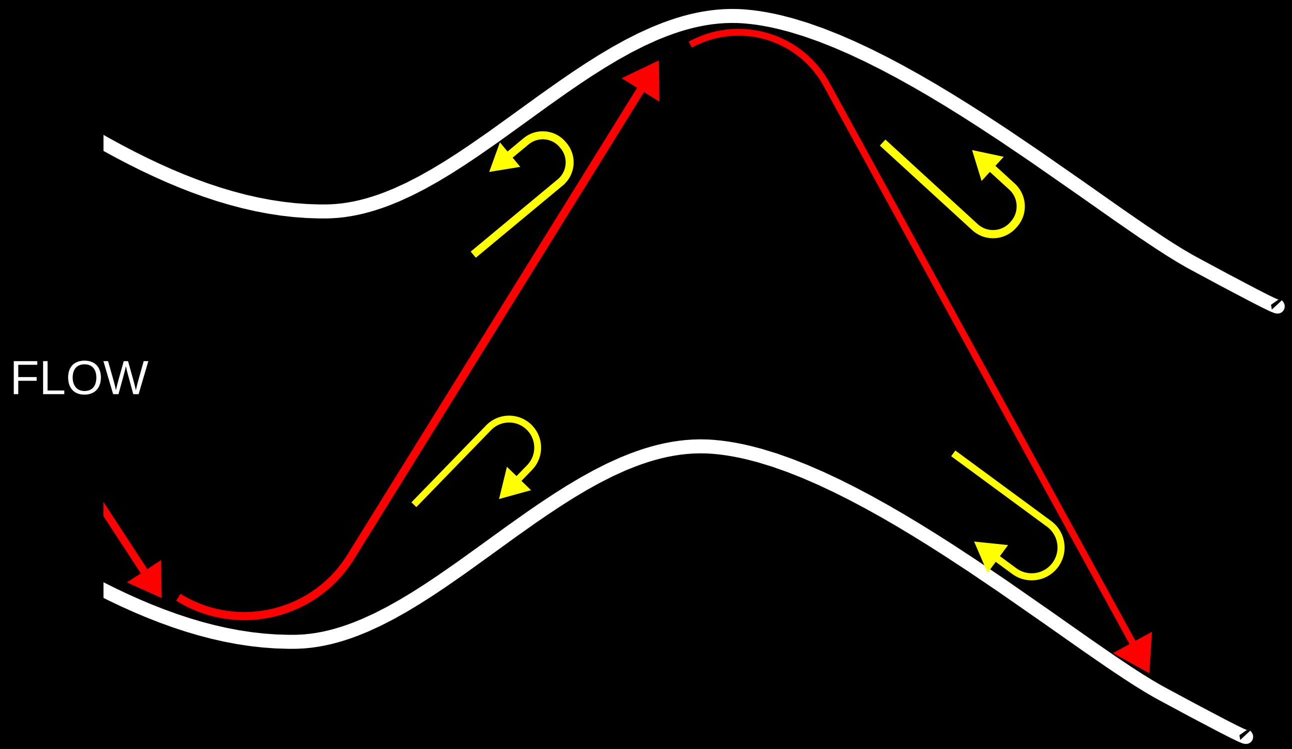
Project involved- Reuben Smit, MS student Auburn University

What to do in an all-sand bed river?

Primary Objectives

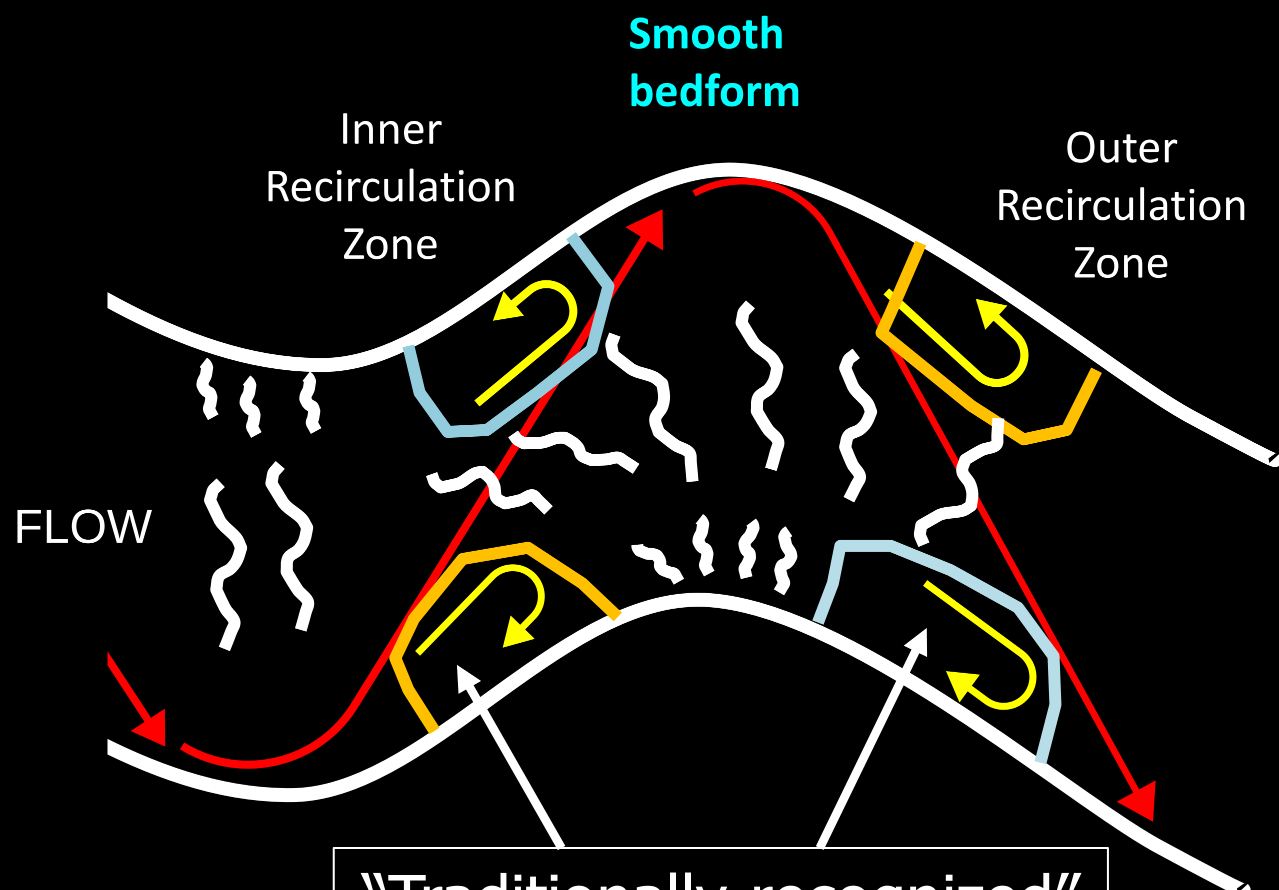
1) **Develop a map that identified suitable mussel habitat throughout a 50 km reach of middle Apalachicola River**
2) **Develop habitat-based, predictive species distribution and abundance models for the endangered fat threeridge (*A. neisleri*)**

Flow refugia in large alluvial rivers



Used by many aquatic organisms

Flow Refugia and Bedform

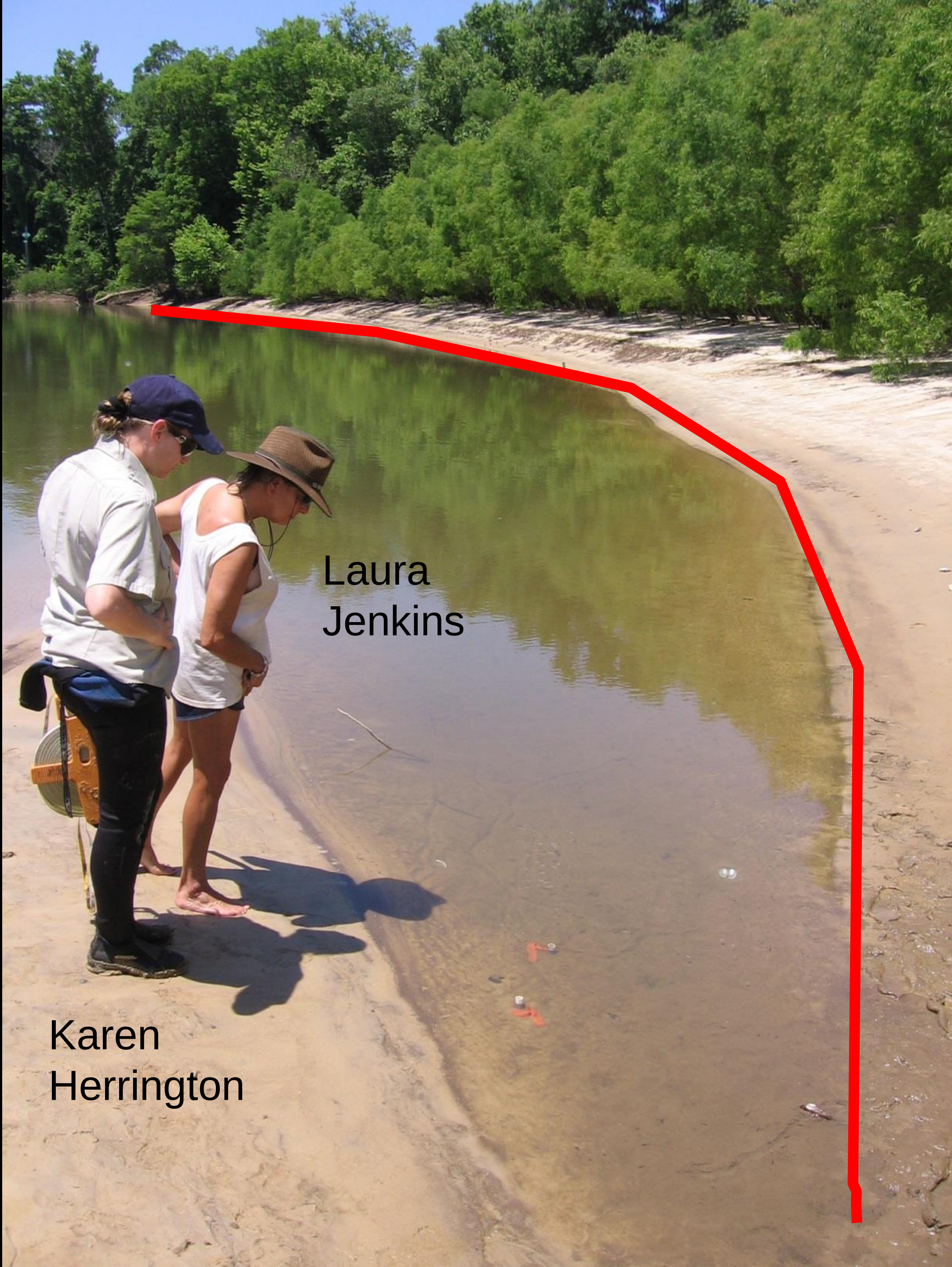


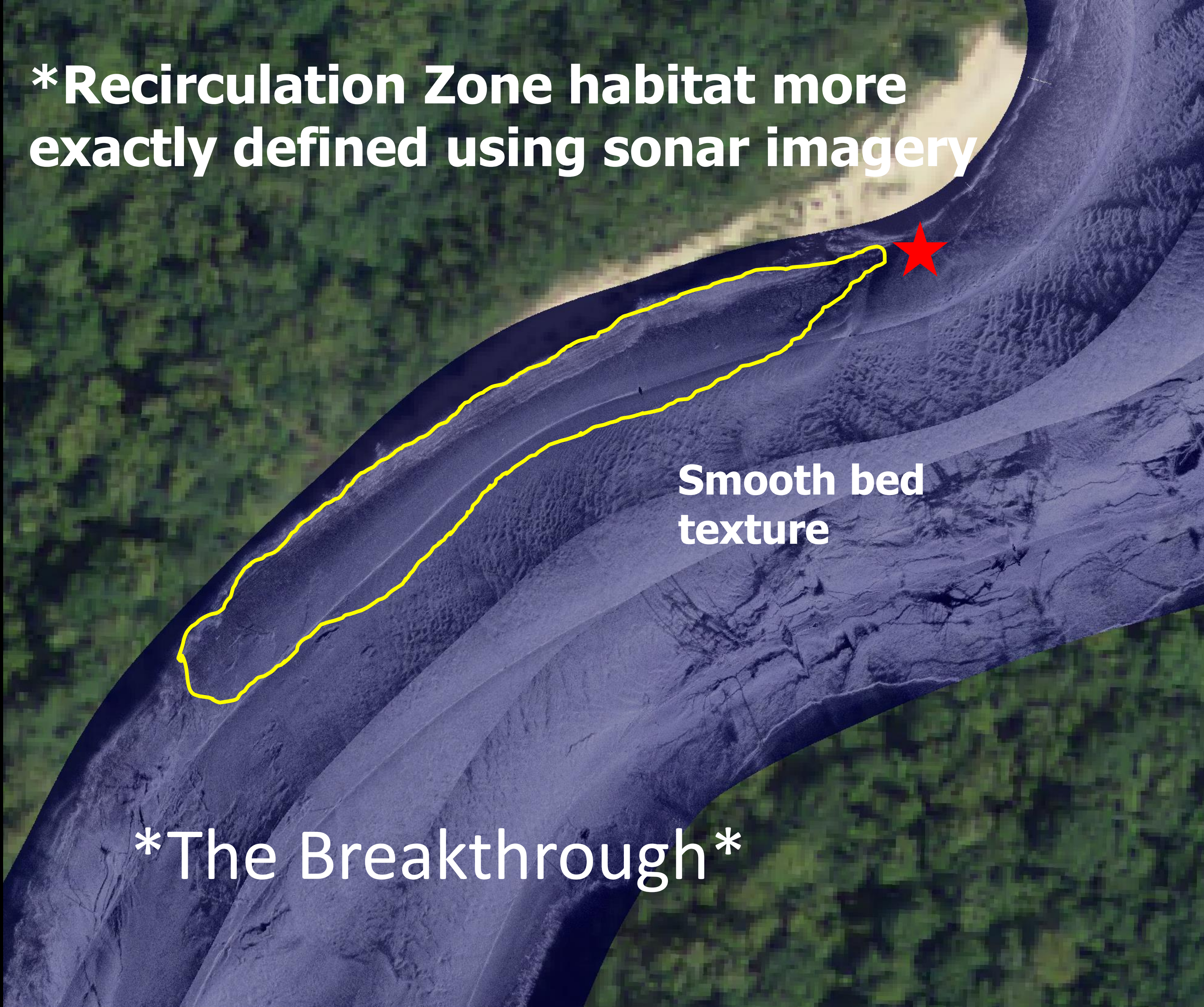
“Traditionally-recognized” mussel habitats

“Traditionally-recognized” mussel habitat

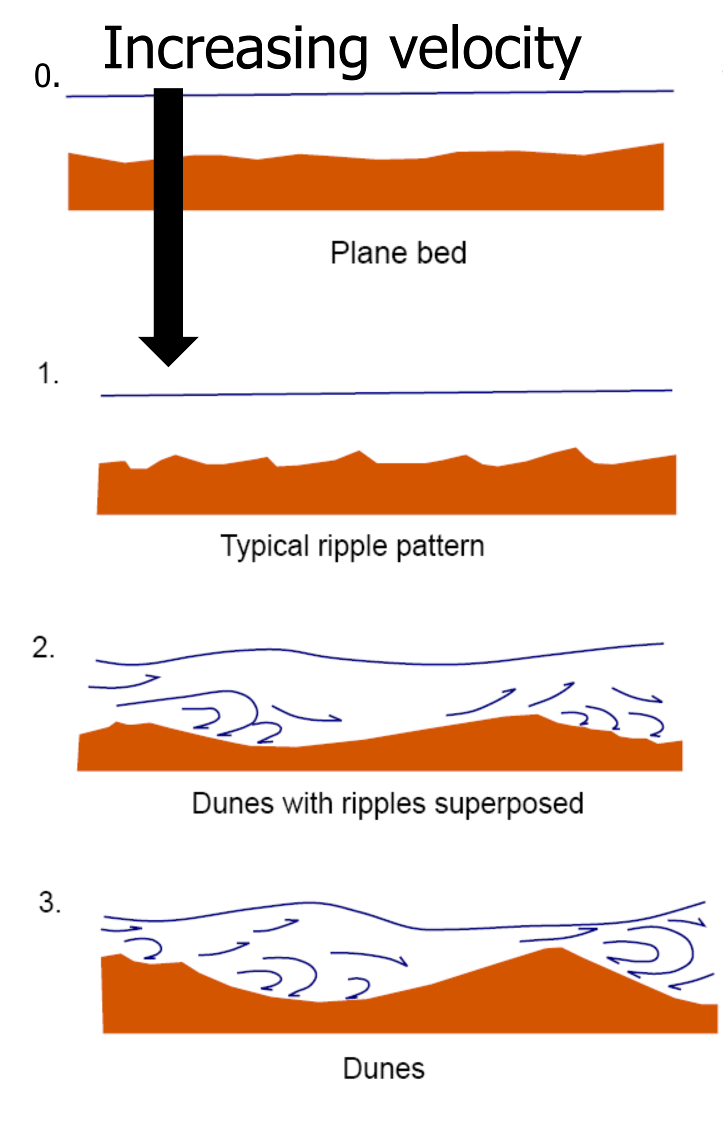
*Focus on shallow portion of these habitats led to flawed <u>Paradigm</u>>

Most mussels occur in narrow band along bank; at-risk from drawdown




*Recirculation Zone habitat more exactly defined using sonar imagery
Smooth bed texture
The Breakthrough

*In Sand-bed Rivers



Bedforms =

shear stress X substrate

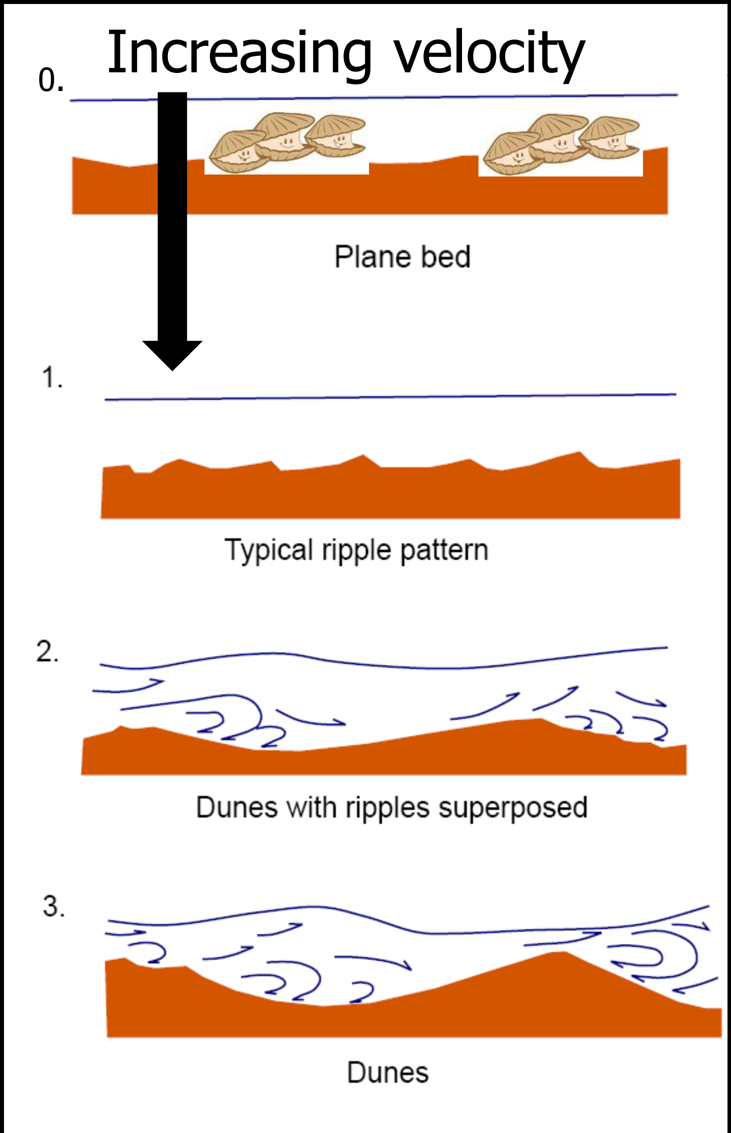
at sediment/water interface

Bedforms =

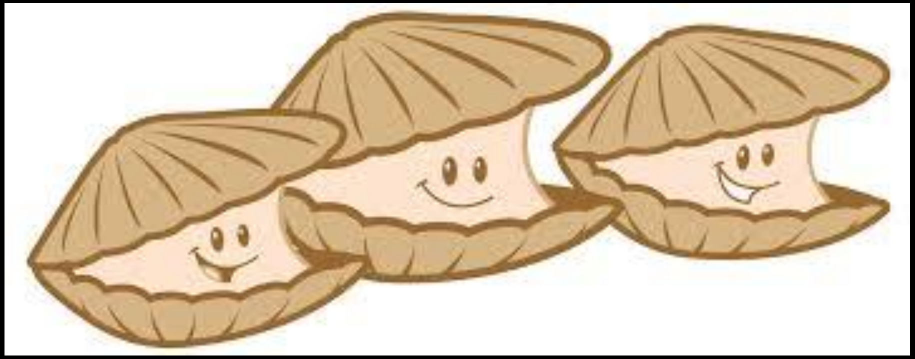
shear stress X substrate

at sediment/water interface

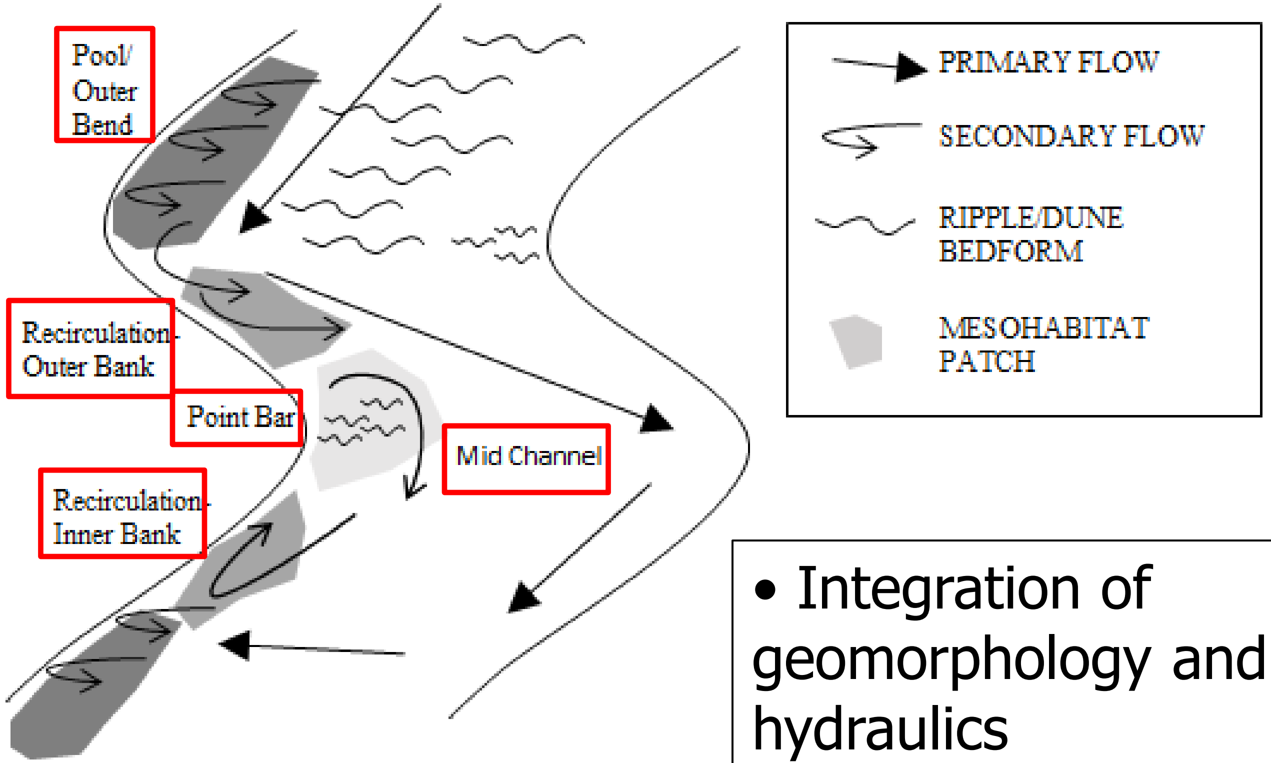
***In Sand-bed Rivers**



***Mussels are happy in stable benthic environments**



Meso-scale Habitat Classification Scheme



- Integration of geomorphology and hydraulics

Figure 3. Conceptual illustration of the primary and secondary flow environments around a meander bend and associated habitat units used for this classification. Adapted from Garcia et al 2012.

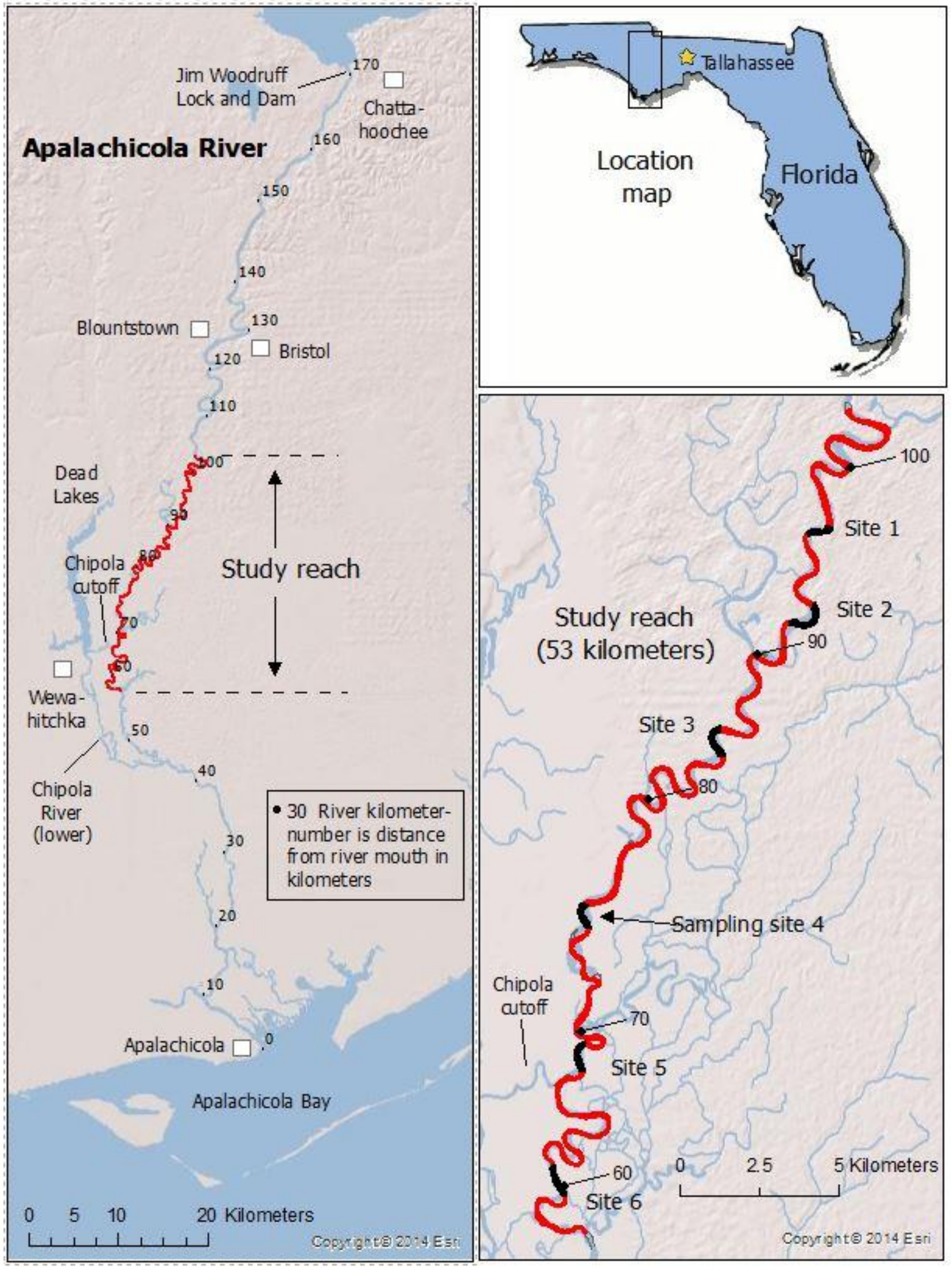
Sonar Survey- March 2012

- **Woodruff Dam to ICW**
- **3+ parallel transects**

2012 Focal Area

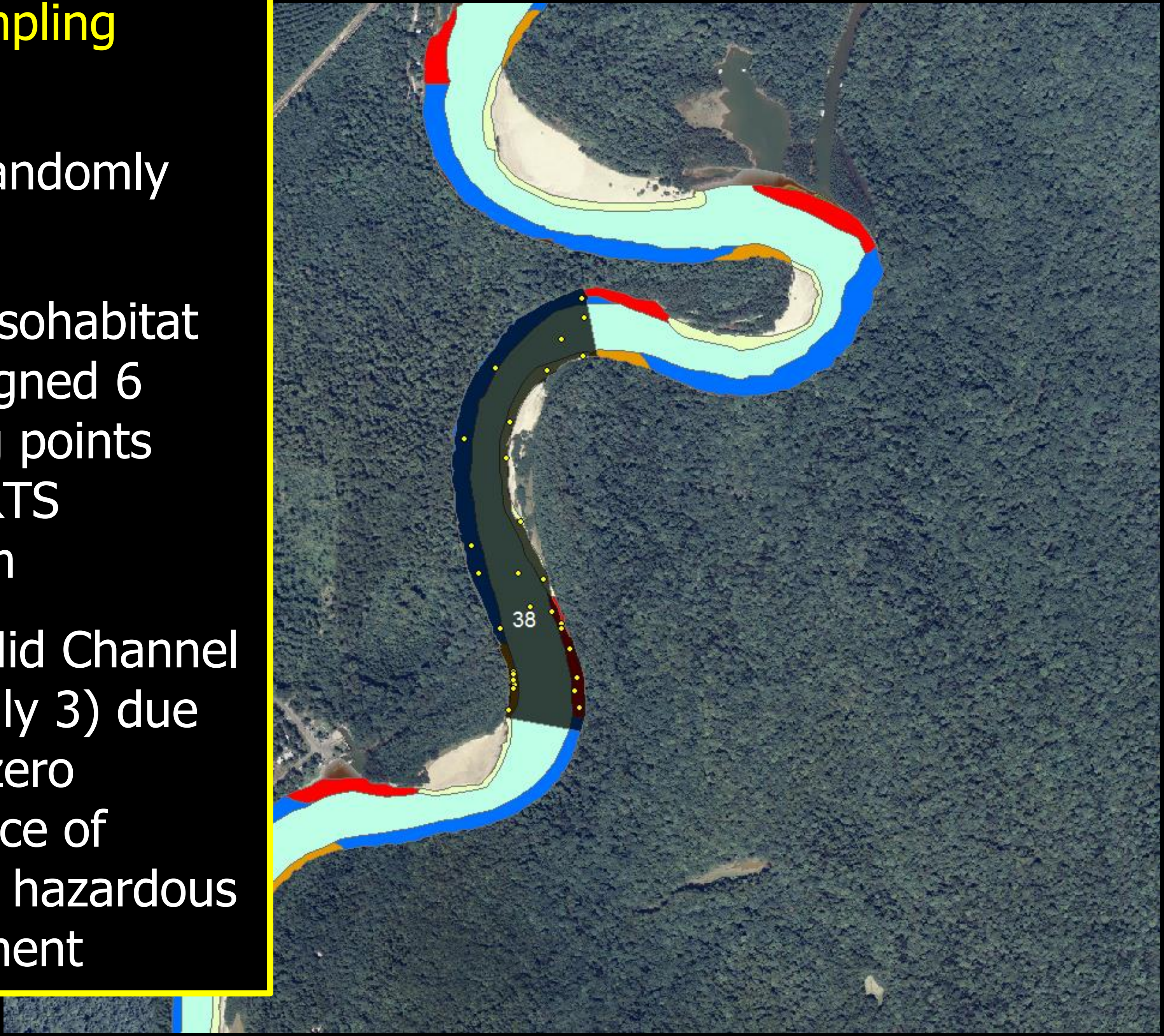
Middle Apalachicola, RM 35-65 RKm 56-103

47 km total



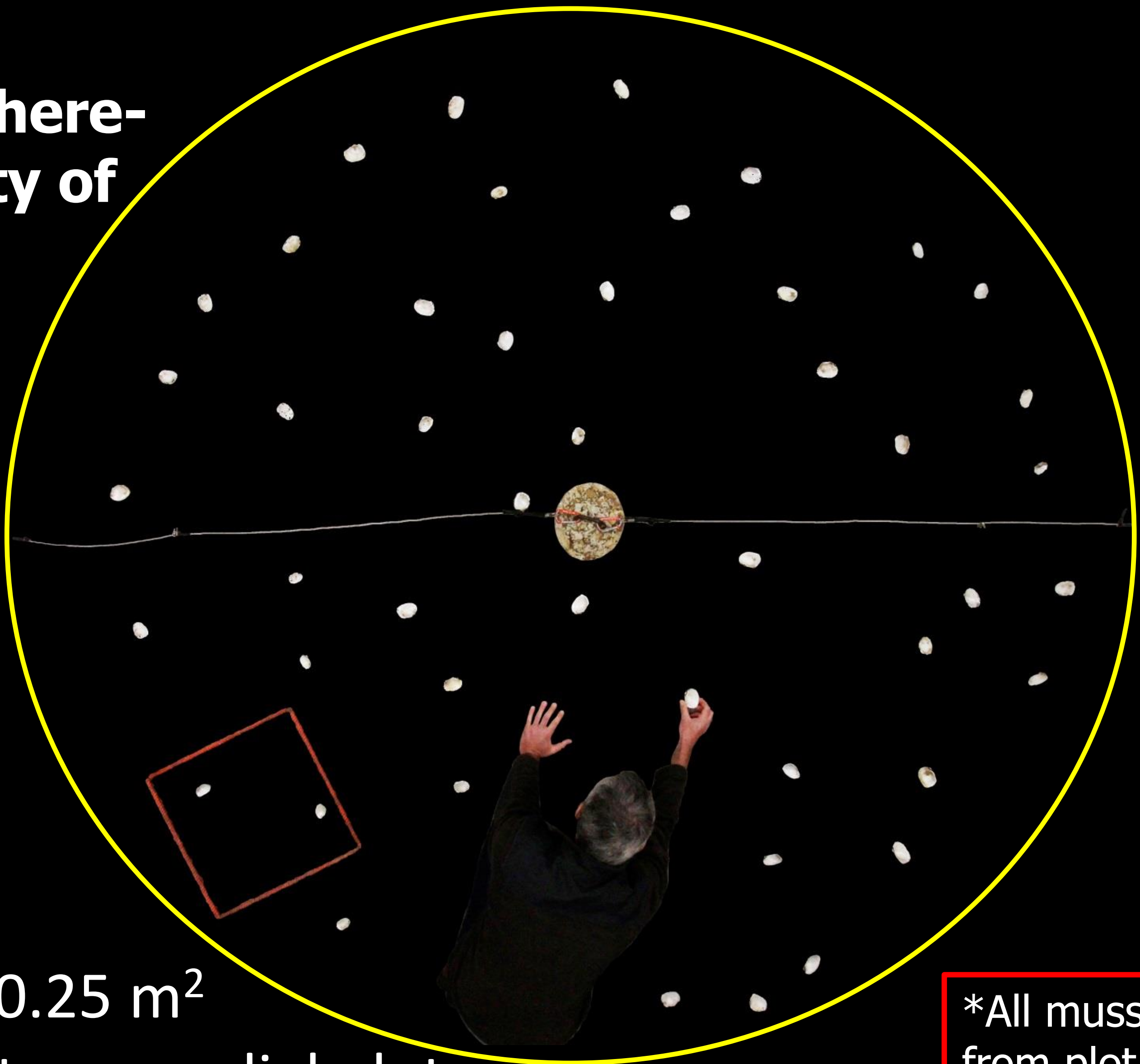
Mussel Sampling Design

- 6 sites randomly selected
- Each mesohabitat was assigned 6 sampling points using GRTS algorithm
- Except Mid Channel class (only 3) due to near-zero abundance of mussels, hazardous environment



Sampling Unit   10m^2 Radial Plot

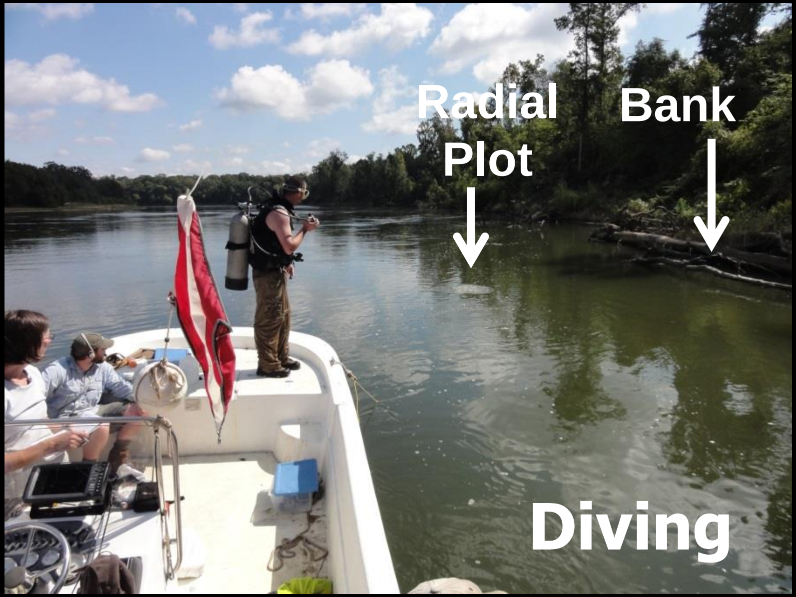
Shown here- a density of 4.7/m^2

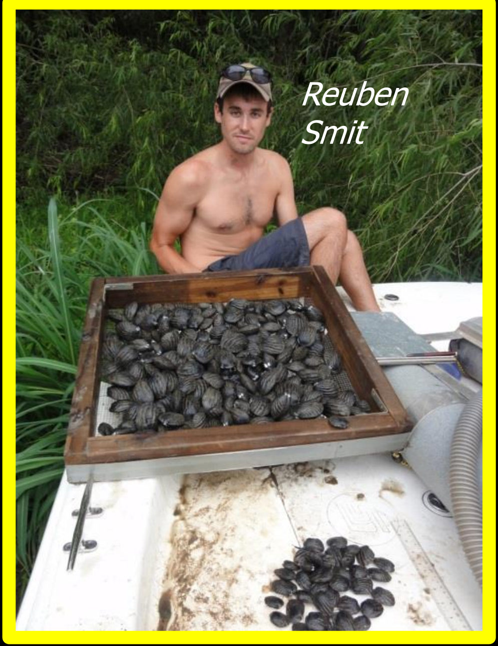


Quadrat= 0.25 m^2
40 quadrats per radial plot

*All mussels excavated from plot; no time limit

Mussel Sampling- Summer 2012
low flows ~5 kcfs





2012 Middle Apalach Collection

Table 5. Mussel species collected during the survey, listed in order of decreasing relative frequency of occurrence among samples collected in the Inner Recirculation Zone (IRZ), Outer Recirculation Zone (ORZ), and Pool/Outer Bend (POB) mesohabitats. The acronyms MC and PB refer to the Mid channel and Pool/Outer Bend mesohabitats, respectively. Each sample represents a collection of mussels within a 10 m^2 radial plot.

			Relative frequency of occurrence			
Species	Total collected	% freq of total collected	Among samples from IRZ, ORZ, and POB	% freq	Among samples from MC and PB	% freq
Amblema neislerii	3958	0.345	90	0.882	8	0.129
Elliptio pullata	2829	0.247	75	0.735	4	0.065
Lampsilis floridensis	590	0.052	75	0.735	11	0.177
Glebula rotundata	3472	0.303	68	0.667	5	0.081
Quadrula infucata	392	0.034	59	0.578	10	0.161
Elliptio crassidens	104	0.009	26	0.255	1	0.016
Villosa vibex	30	0.003	14	0.137	2	0.032
Elliptoideus sloatianus	24	0.002	13	0.127	0	0
Megalonaias nervosa	12	0.001	8	0.078	0	0
Villosa villosa	25	0.002	8	0.078	3	0.048
Elliptio arctata	10	0.001	5	0.049	0	0
Pyganadon grandis	5	0.0004	5	0.049	0	0
Toxalasma paulum	5	0.0004	5	0.049	0	0
Anodonta heardi	3	0.0003	3	0.029	0	0
Utterbackia imbecillis	3	0.0003	3	0.029	0	0
Alasmidonta triangulata	1	0.0001	1	0.010	0	0
Elliptio chipolaensis	1	0.0001	1	0.010	0	0
Utterbackia peggyae	1	0.0001	1	0.010	0	0
Total collected	11465		n= 102 samples		n= 62 samples	

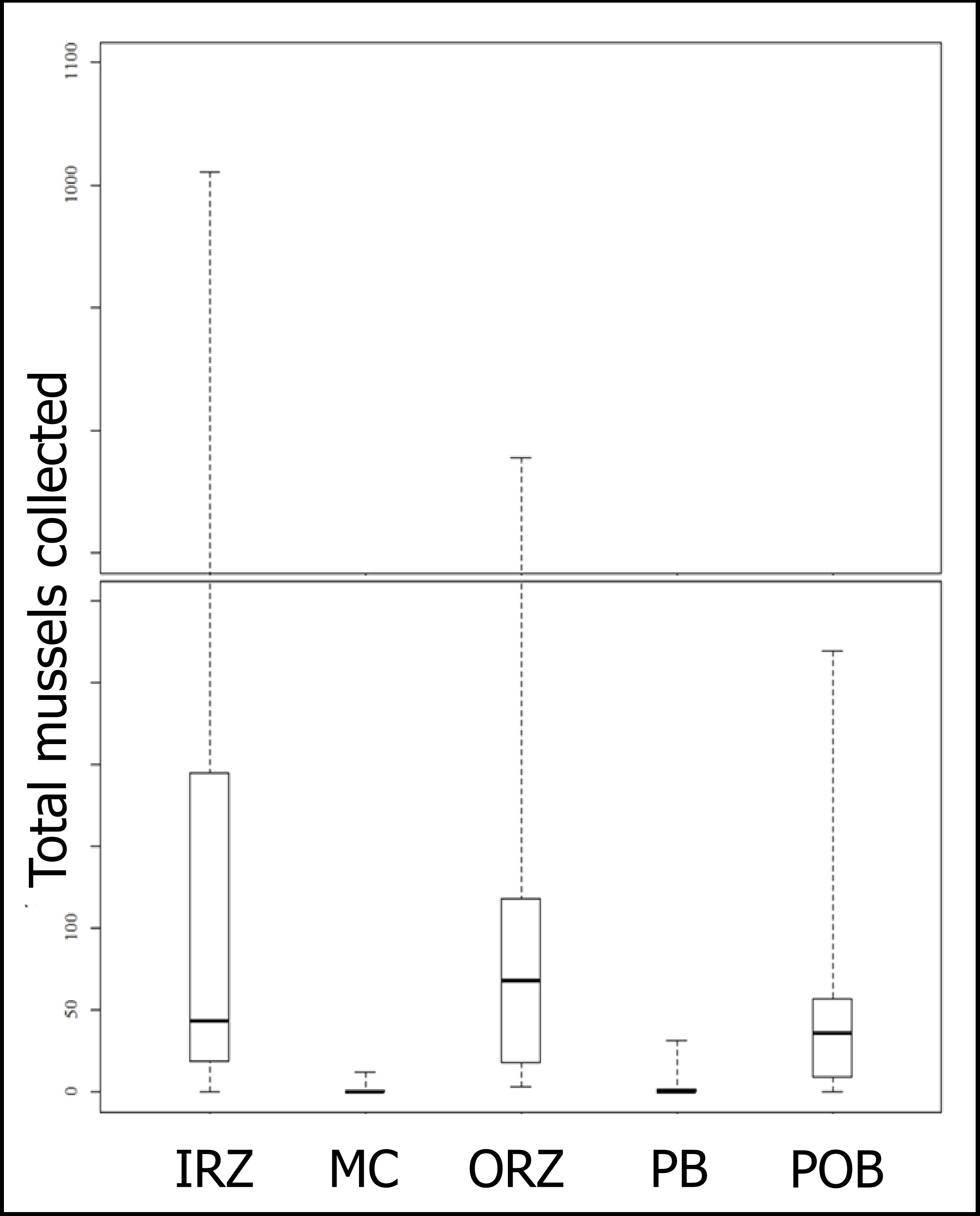
*1,640 m^2 of habitat sampled in 2012

Equivalent to 6,560 quadrats

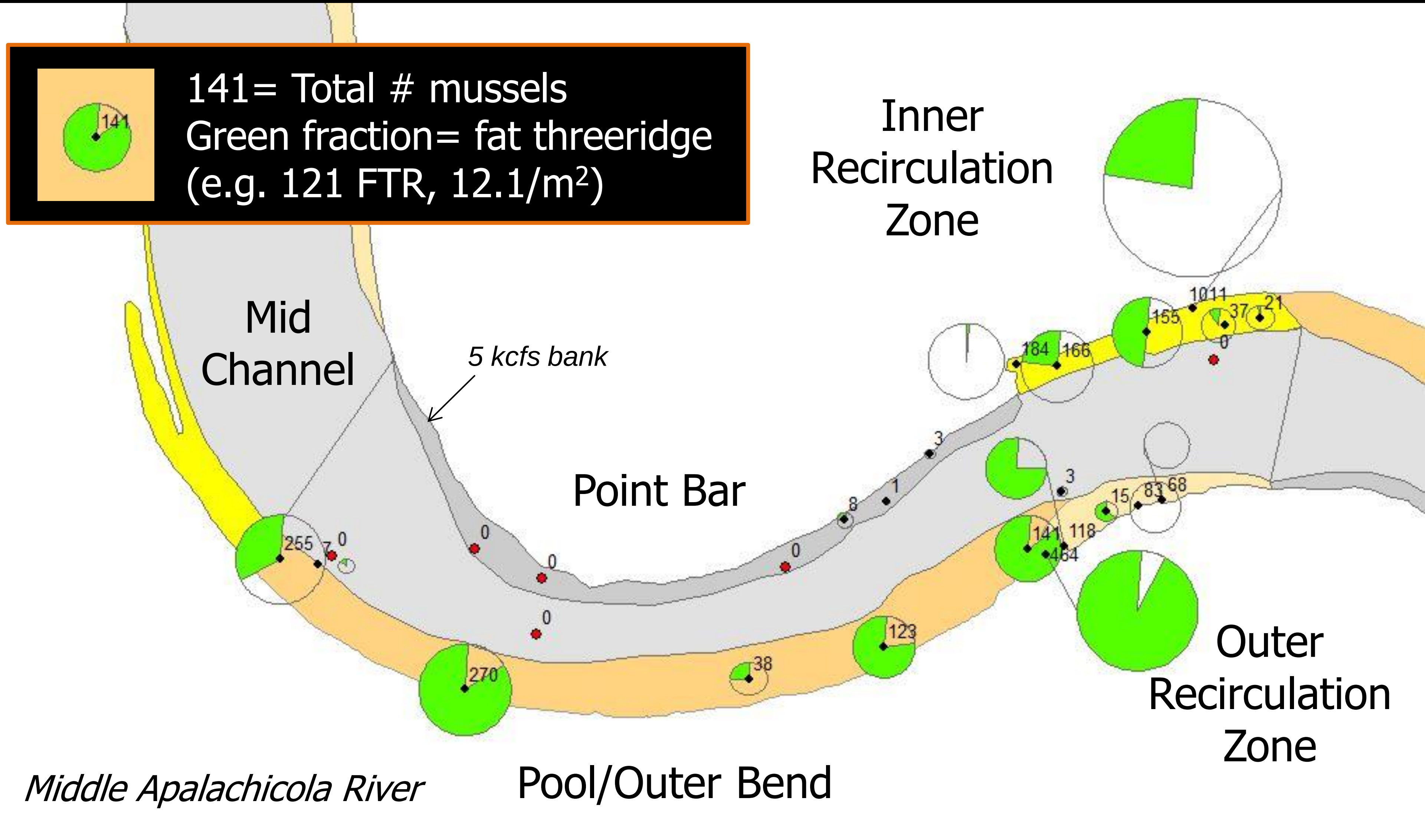
2008/2010 M. Gangloff sampled 256 m^2, 1,025 quads in same reach

Key Finding

Using only SSS and bedform patterns, we clearly differentiated suitable from non-suitable mussel habitat across a 50 km riverscape



Mussel Abundance at RM 46.3-46.7



A. neislerii simple pop estimate

Middle Apalachicola

**Nonparametric Bootstrapped*

Mesohab Class	Area (m^2)	Avg Den (m^2)	Abundance
Point Bar	505,010	0.86	434,309
Inner Recirc Zone	270,698	4.6	1,239,797
Outer Recirc Zone	157,183	4.8	754,478
Mid Channel	4,985,217	0.0	0
Pool/Outer Bend	1,043,241	3.28	3,421,830

Previous estimate (Gangloff 2012)

- 120,000

Grand Total=5.85 million *A. neislerii*

95% CI (Bootstrap)= 2-6 million

Why such a difference?

Grand Total Millions of *A. neislerii* mussels in Middle Reach

vs

Previous estimate (Gangloff 2012)

120,000

2 Primary Reasons-

1) IRZ/ORZ habitats are larger and more numerous, and mussels occur throughout

2008/2010> 43 sites/patches, 4.7 hectares
2012> 101 sites/patches, 43 hectares

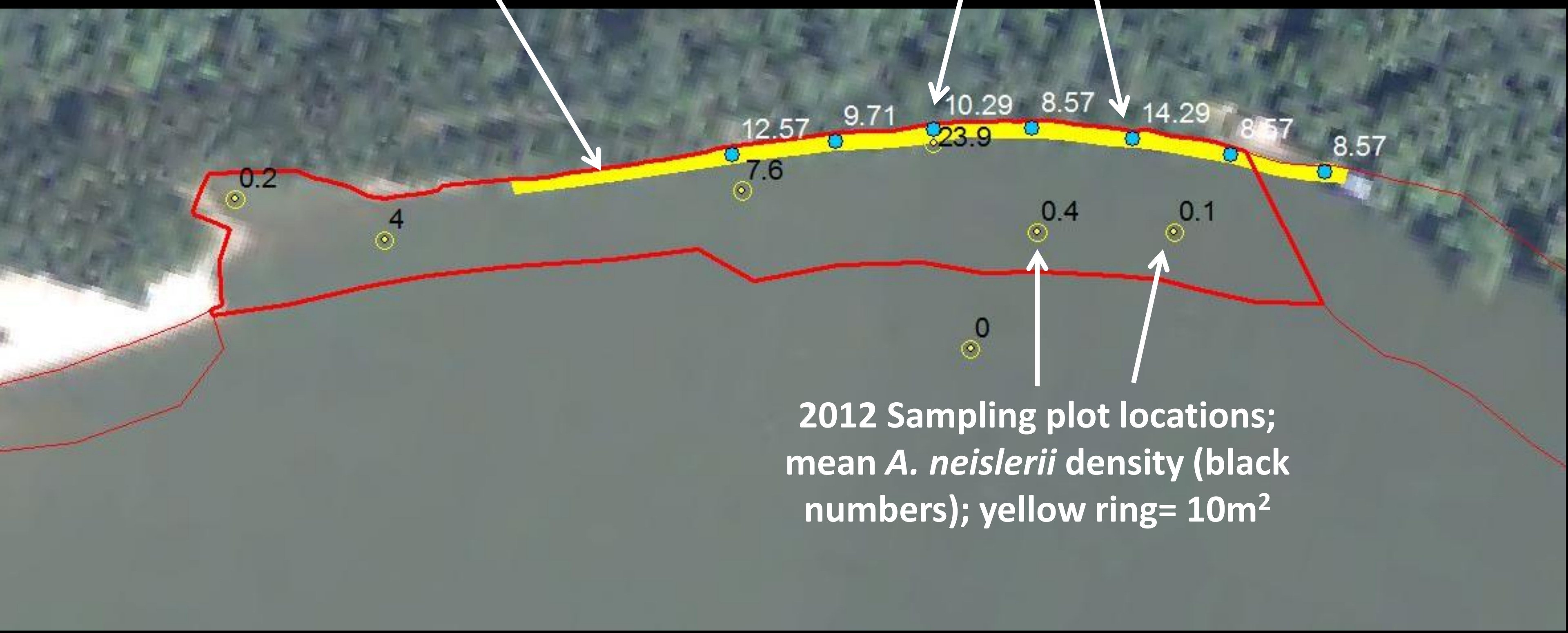
MUCH more occupied habitat than previously thought

2) Mussels throughout expansive (104.3 total hectares) Pool/Outer Bend habitat

Near-bank focal area vs. entire IRZ of 2012 Map

Yellow band= near-bank habitat sampled

Transect locations; sampled to 1m deep; mean *A. neislerii* density (white numbers)



2012 Sampling plot locations; mean *A. neislerii* density (black numbers); yellow ring= $10m^2$

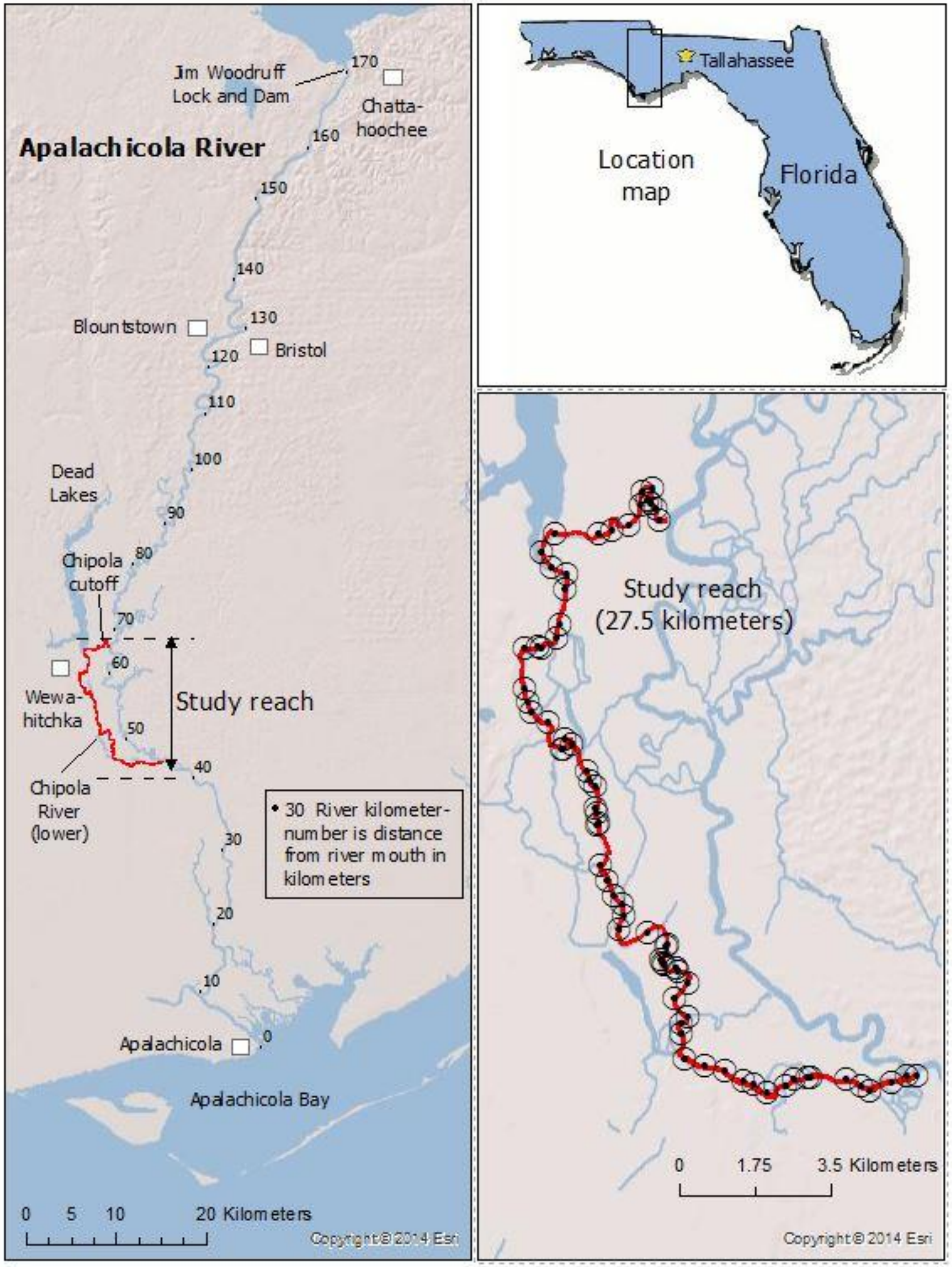
1st Expansion

2014 Focal Area

Lower Chipola River

27.5 km total

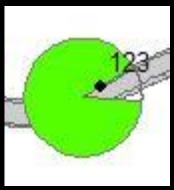
Same methods; except distribute sampling plots throughout, $5m^2$ plot



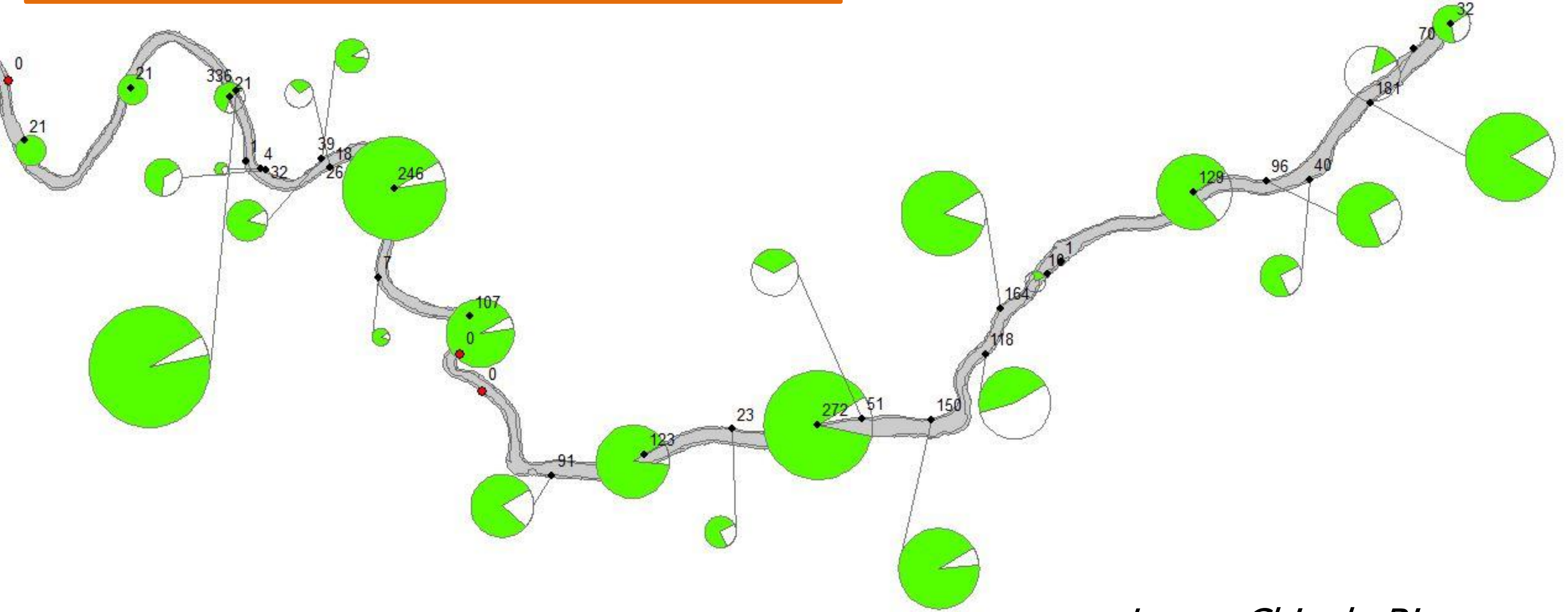

mares
NRS


O'NEILL

Mussel Abundance at RKm 0-12



123= Total # mussels
Green fraction= fat threeridge
(e.g. 111 FTR, 22.2/m^2)



A. neislerii simple pop estimate

Lower Chipola River (area adjusted for low flow)

Mesohab Class	Area (m^2)	*Nonparametric bootstrapped* Avg Den (m^2)	Abundance
Smooth bank-attach	382,000	11.2	4,278,000
Pool Outer Bend	282,000	11.0	3,102,000
Mid Channel	1,265,849	0.17	
Total Suitable Habitat	664,000		

Grand Total 7.3 million *A. neislerii* mussels

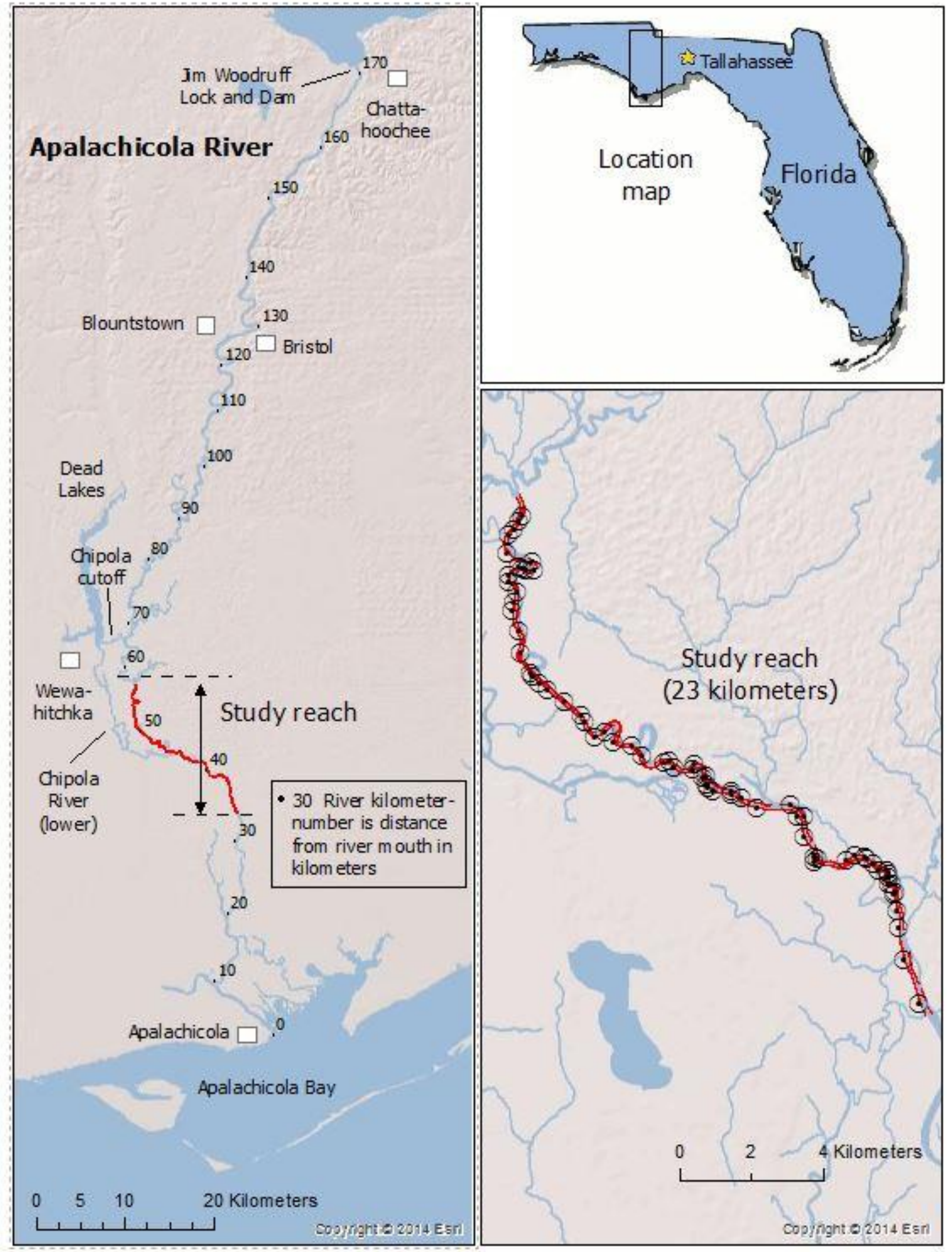
95% CI= 3-11 million

2nd Expansion

2015 Focal Area

Lower Apalachicola River

RM 20.7-35
RKm 33-56

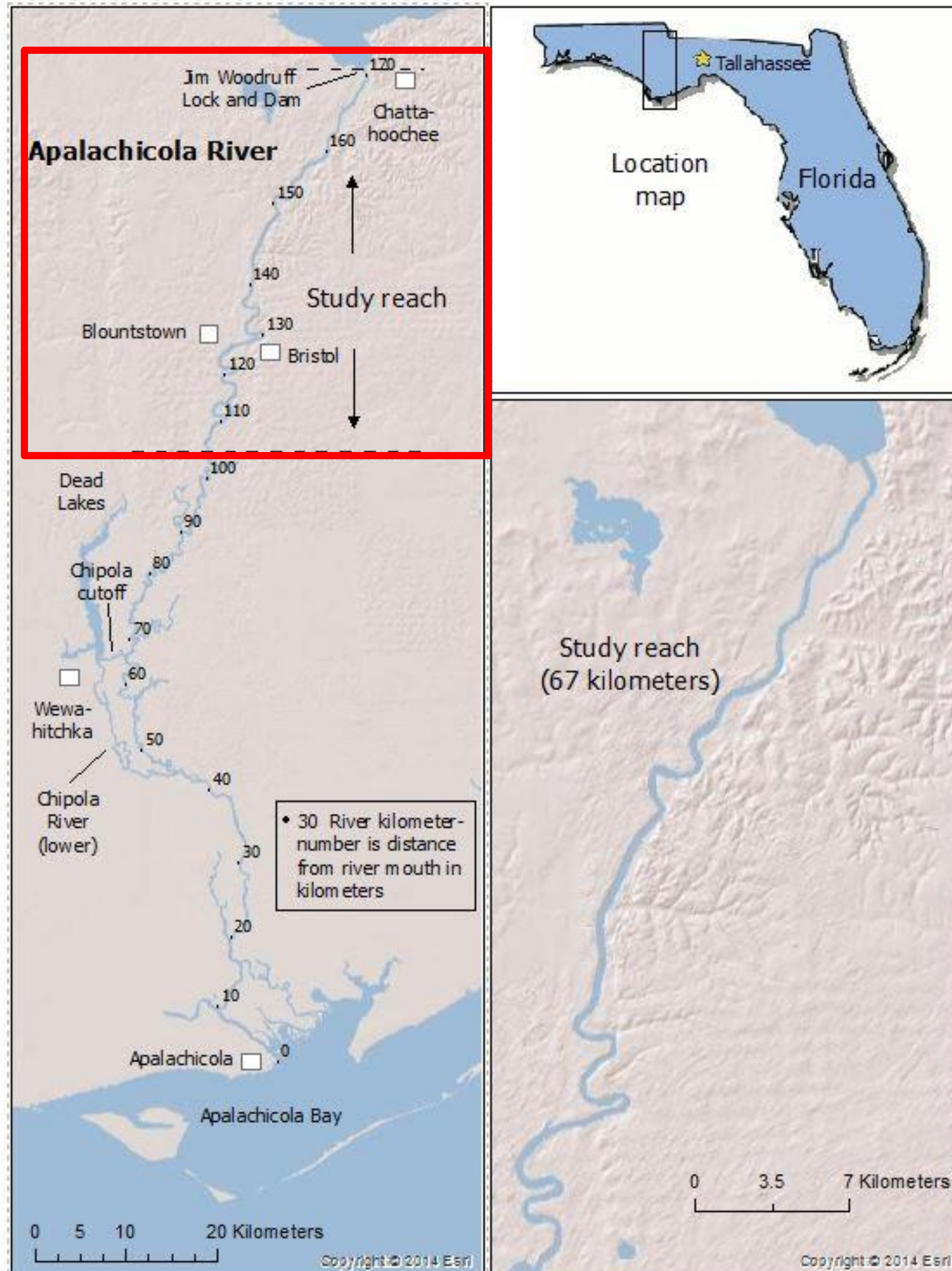


3rd Expansion?

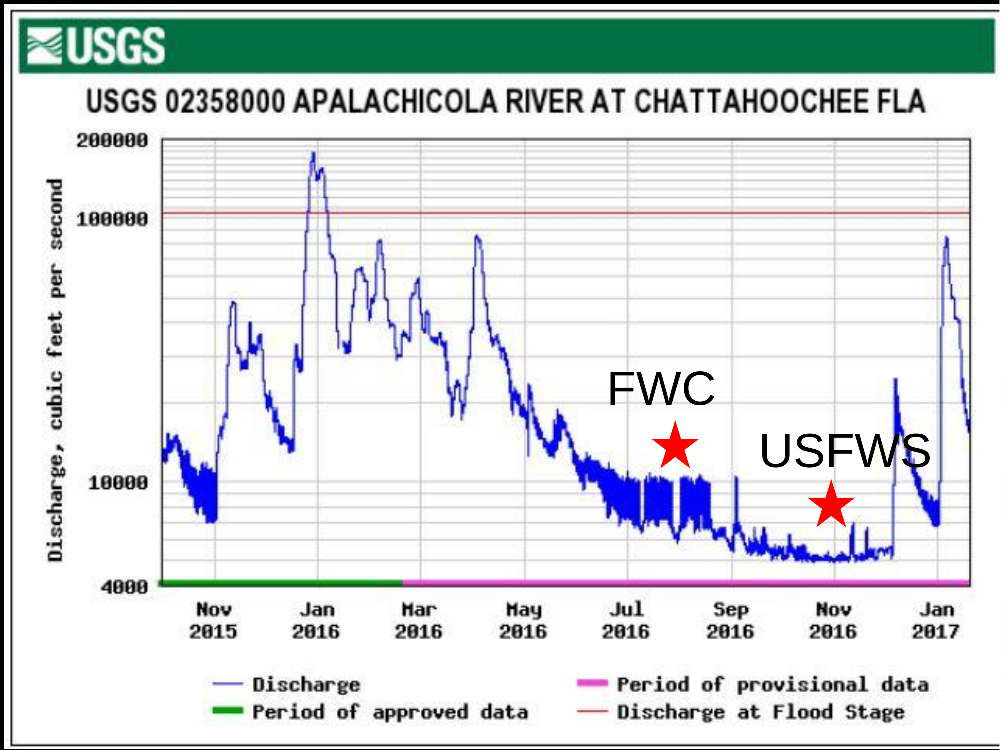
2017 Focal Area

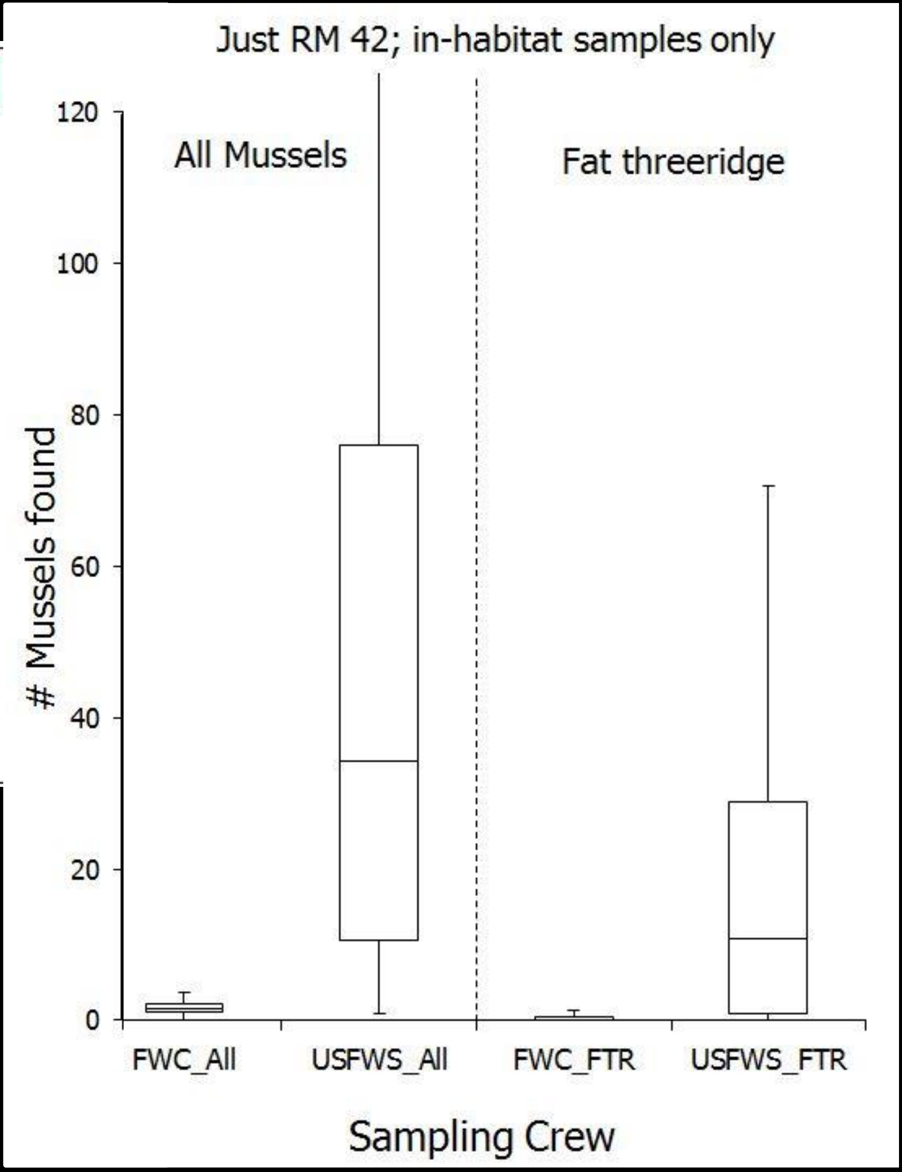
Upper Apalachicola River

RM 65-
RKm 66-170



Flood Effects?





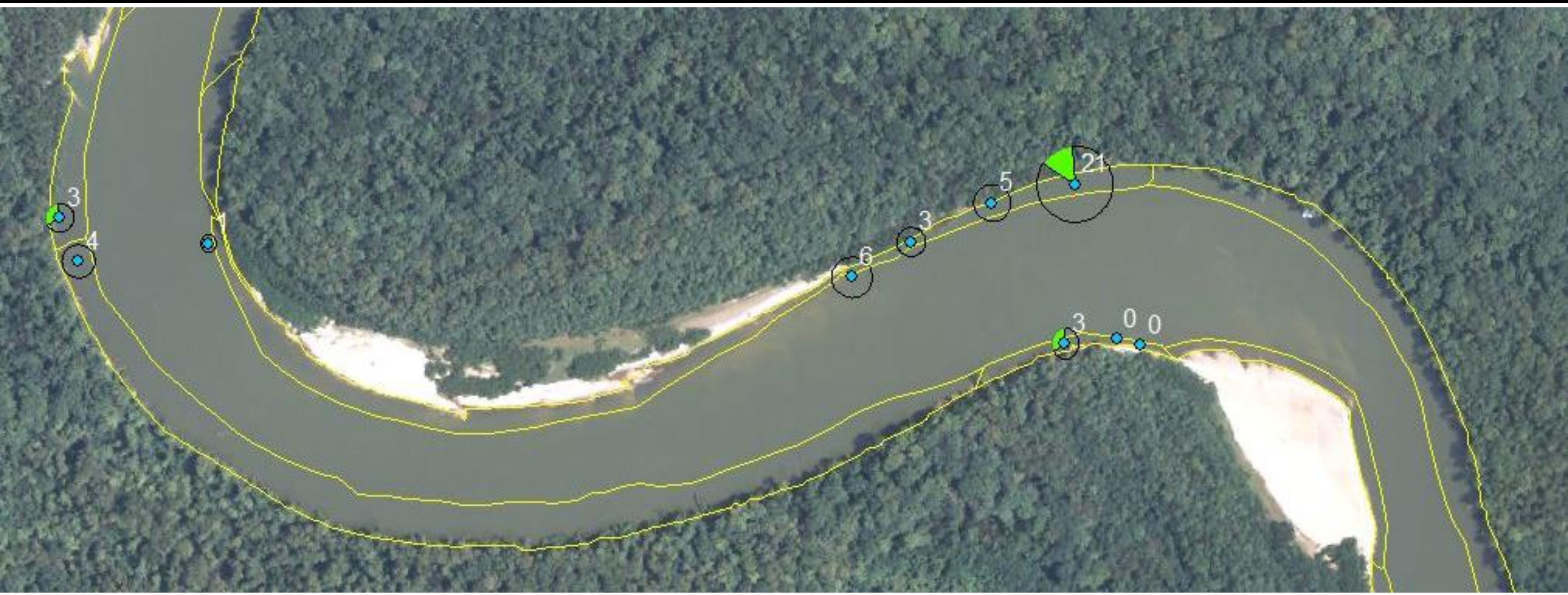
FWC Sampled August 2016

USFWS Sampled Nov 2016

FWC Mussel Sampling Results RM 42

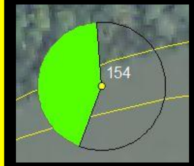
August 2016

21= Total # mussels
Green fraction= fat threeridge
(e.g. 3 FTR, $0.3/m^2$)

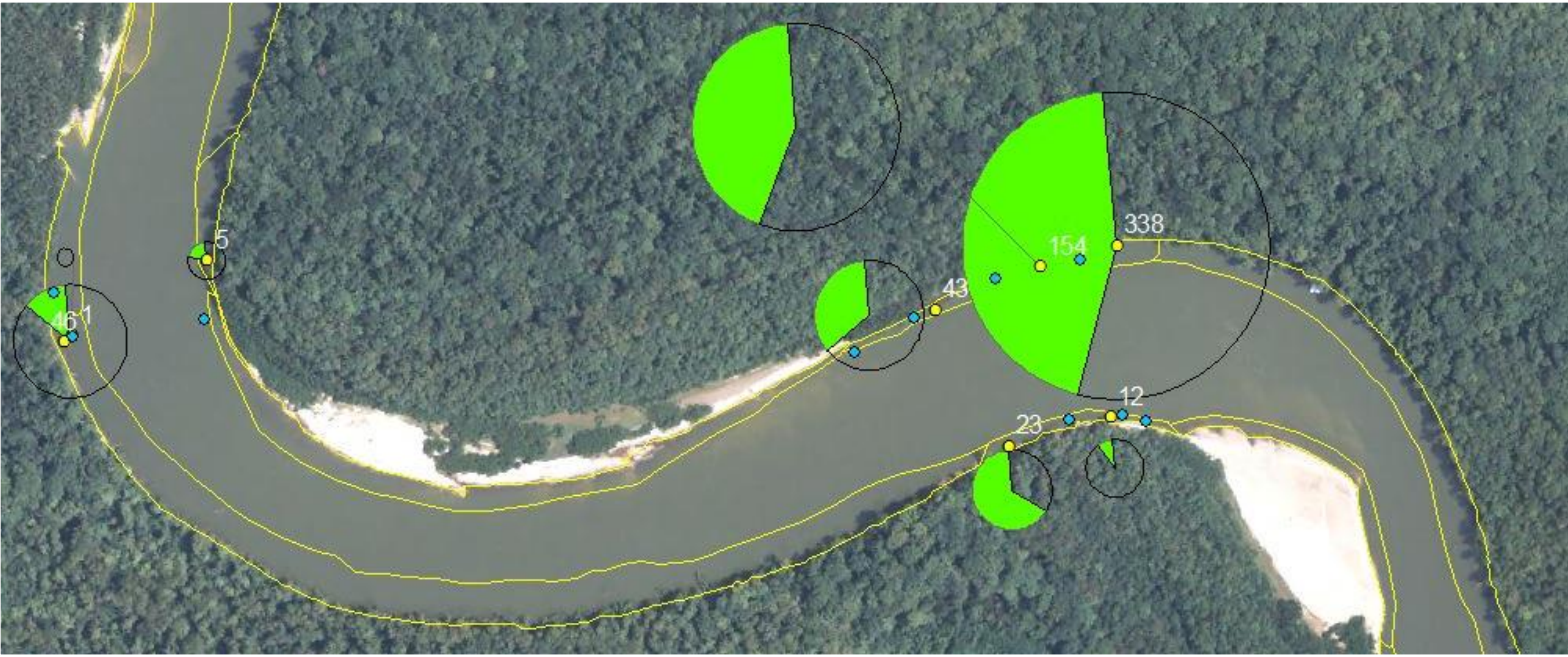


USFWS Mussel Sampling Results RM 42

Nov 2016



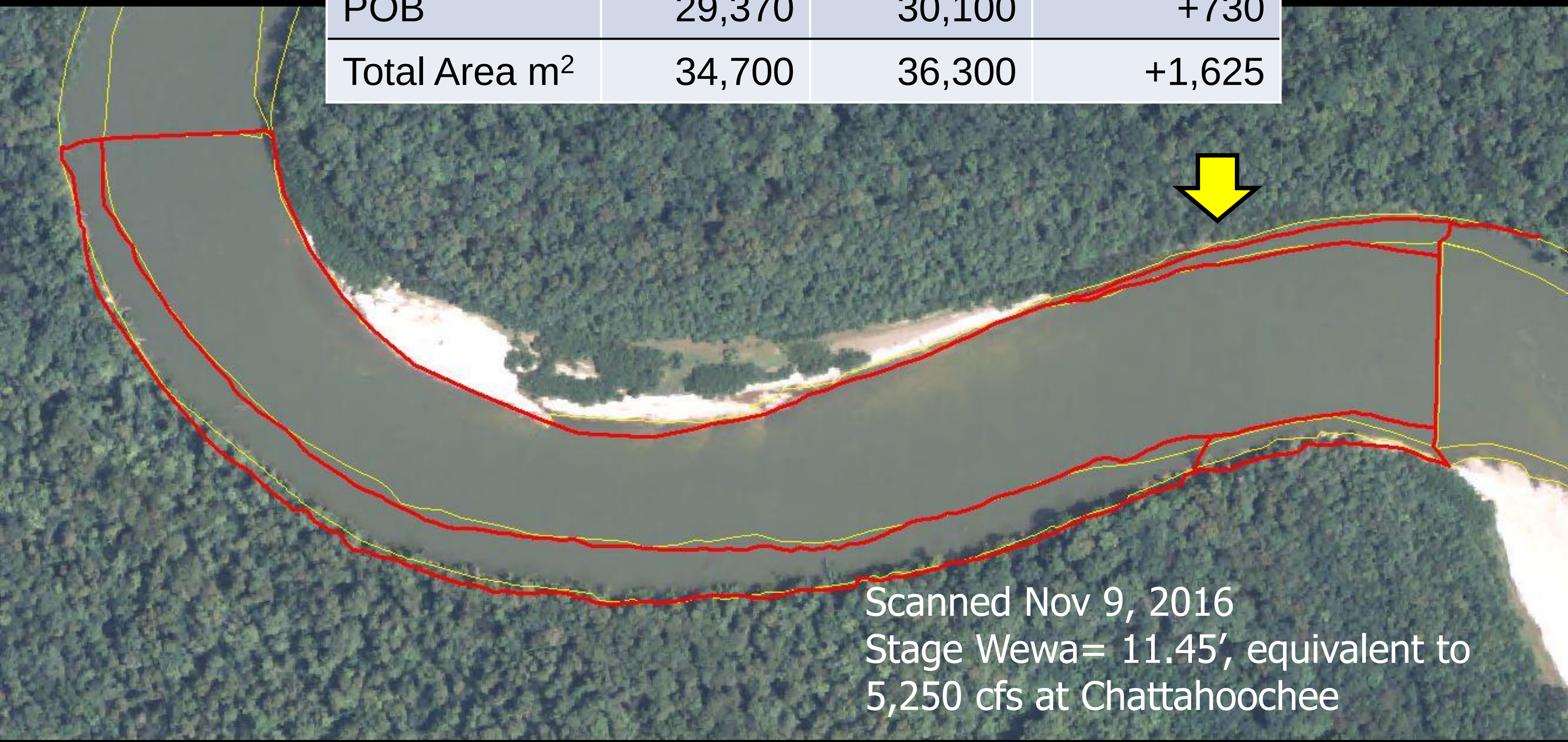
154= Total # mussels
Green fraction= fat threeridge
(e.g. 66 FTR, $13.2/m^2$)



Blue dot= FWC; Yellow Dot= USFWS

Remapping Results RM 42

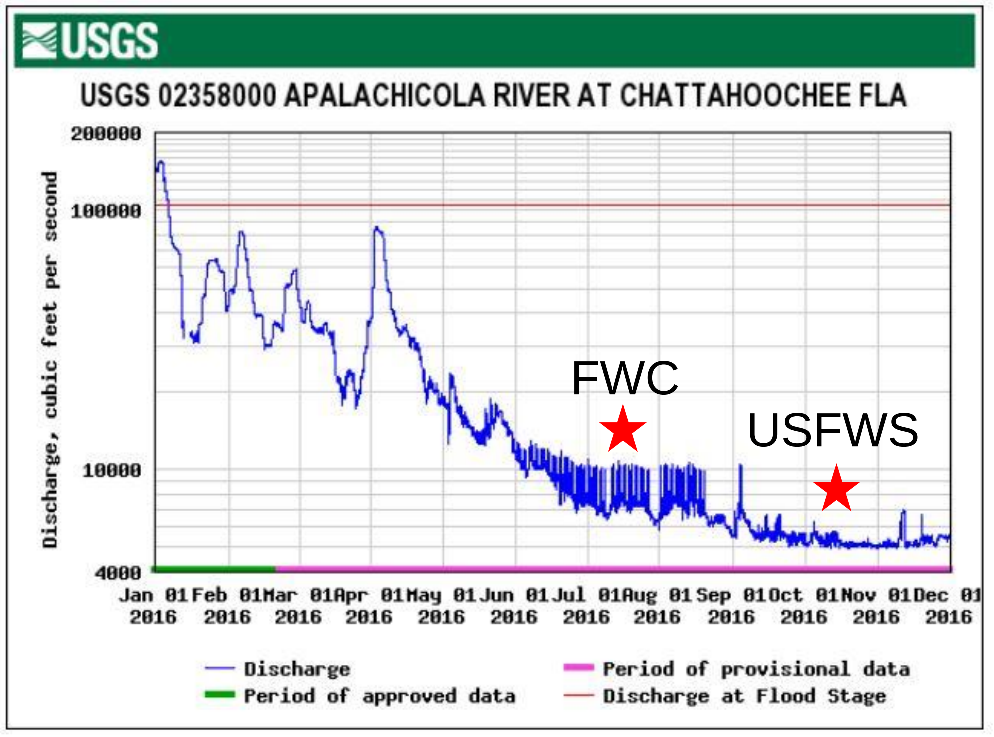
Mesohabitat	2012 Map	2016 Map	Difference
IRZ	3,690	2,940	-755
ORZ	1,640	3,290	+1,650
POB	29,370	30,100	+730
Total Area m^2	34,700	36,300	+1,625

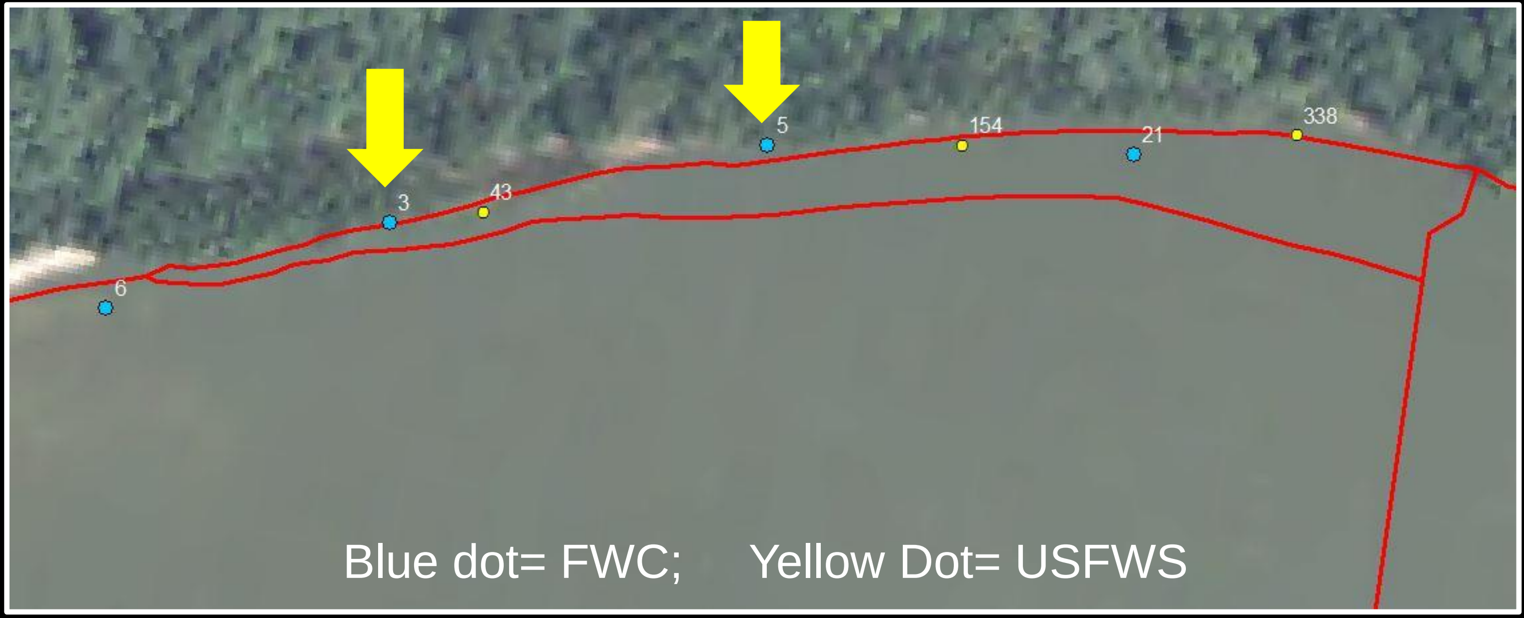


Importance of sampling <u>in</u> the habitat

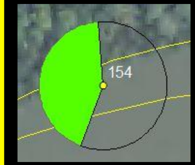
FWC 8/17/2016; stage Wewa was 14.25', equivalent 8,800 cfs at Chattahoochee gage

USFWS 11/9-11/10/16; stage Wewa was 11.45', equivalent to 5,250 cfs at Chatt gage

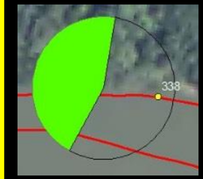




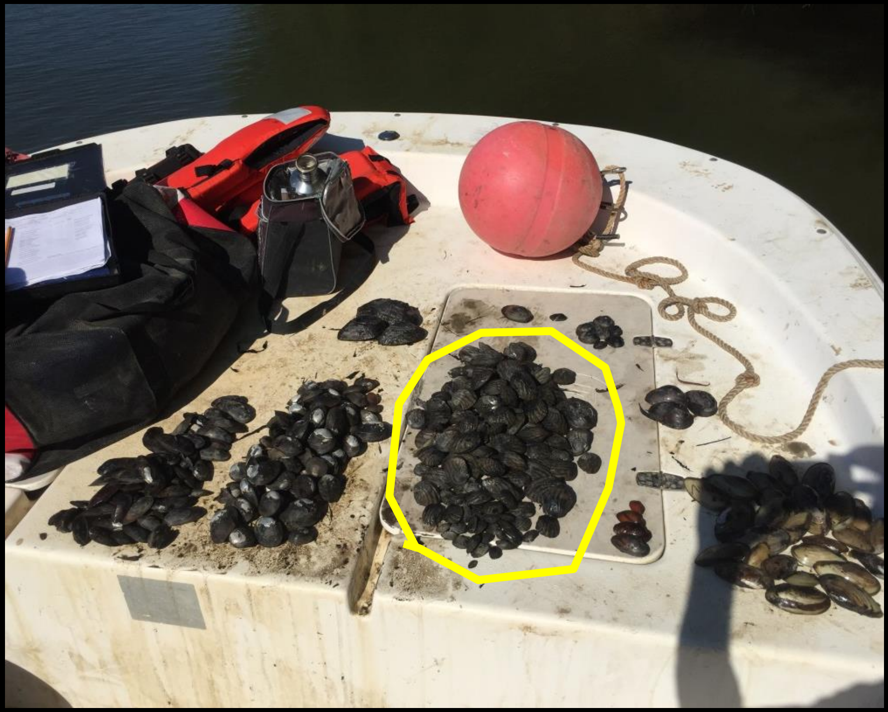
Success, below the 5kcfs elevation



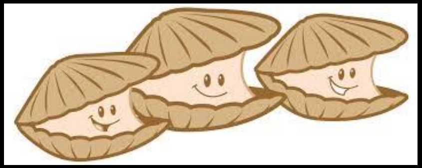
154= Total # mussels
Green fraction= fat threeridge
(e.g. 66 FTR, 13.2/m^2)



338= Total # mussels
Green fraction= fat threeridge
(e.g. 151 FTR, 30.2/m^2)



New Era, New Paradigm



- Published method for mapping, quantifying, monitoring mussel habitat over time in lower ACF and elsewhere
- Quantitative, statistically robust approach to describe mussel distribution and abundance within <u>all habitats</u> of this large Coastal Plain river system
- Larger RZ habitats, pools occupied, mussels @ greater distances from bank, @ greater depths

Published in Freshwater Science, Sept 2016

Defining freshwater mussel mesohabitat associations in an alluvial, Coastal Plain river

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[1]Auburn University, School of Fisheries, Aquaculture and Aquatic Sciences, Auburn, Alabama 36849 USA
[2]US Fish and Wildlife Service, Panama City Fish and Wildlife Conservation Office, Panama City, Florida 32405 USA

Abstract: Defining freshwater mussel habitat in large, turbid rivers is challenging but essential to effective conservation. Hydraulic investigations have confirmed that mussels persist in discrete flow refugia, areas where riverbed sediment is stable during high-discharge events. However, approaches to identify these patches often involve detailed field measurements or mathematical models that may limit their applications across wide spatial extents. We used low-cost, sonar habitat mapping to delineate a mesohabitat classification scheme based primarily upon variations in substrate bedforms and position within the river channel. Bedforms in sand-bed rivers function as indicators of turbulent flow and hydraulic conditions at the sediment–water interface. We used the resulting map to conduct a stratified mussel survey to assess mussel–habitat associations at multiple scales. In addition, we assessed habitat persistence by remapping a portion of the study area following flood-level discharge events and conducting a time-lapse, change-detection analysis. We found strong relationships between freshwater mussel occurrence and mesohabitat type and between mussel abundance and variables such as distance to low-flow bank, distance to unstable habitat, and distance from the river mouth. Mussels were found throughout recirculation-zone mesohabitats, areas of the channel traditionally recognized as flow refugia, but also were found unexpectedly throughout pool/outer bend mesohabitats. The sonar mapping approach identified 2× as many patches and 10× the quantity of recirculation-zone habitat in the study area than previously identified using traditional approaches. Mesohabitat boundaries changed little after flood events, further explaining the widespread occurrence of mussels throughout habitats characterized simply by their smooth/plane bedform appearance in sonar imagery. The mesoscale approach demonstrated in our study is a strategy for investigating freshwater mussels and other aquatic organisms in large, turbid rivers.
Key words: freshwater mussel habitat, mesohabitat, side scan sonar, Apalachicola River

Freshwater mussels are among the most imperiled aquatic organisms in North America (Ricciardi and Rasmussen 1999, Strayer et al. 2004). The southeastern USA is home to most of these species, and many inhabit medium-to-large, turbid rivers (Neves et al. 1997, Williams et al. 2008, 2014). Comprehensive knowledge of the distribution and quantity of suitable habitat is fundamental to the conservation of freshwater mussels and the management of ecosystems they inhabit (Haag and Williams 2014), but expanding this knowledge in navigable river systems is challenging using traditional approaches.

Part of this challenge involves identifying suitable habitat at a scale that is relevant to the life history and management of mussels and to the processes that control their distribution and abundance within a given river system (Strayer et al. 2006, Newton et al. 2008). Studies at landscape and reach levels have identified mussel associations with land use, catchment size, stream power, bankfull sheer stress, and channel slope (DiMaio and Corkum 1995, Arbuckle and Downing 2002, McRae et al. 2004, Gangloff and Feminella 2007, Atkinson et al. 2012), but such variables are unlikely to describe the patchiness of mussels that typically occurs at the subreach scale. On the other hand, studies of microhabitat features, such as substrate type and particle size (Hastie et al. 2000, Strayer and Smith 2003, Brim Box et al. 2002), typically are poorly correlated with mussel occurrence or abundance because larger-scale hydrogeomorphologic factors that influence microhabitats are not taken into consideration (Strayer et al. 2006).

Strayer (1999) built on the notion that freshwater mussels inhabit stable substrates (Vannote and Minshall 1982, Young and Williams 1983) and introduced the flow-refuge concept to explain subreach patchiness of mussels in rivers. Flow refugia are discrete areas of the river bed that experience low hydraulic stress and remain stable during flood events. Studies involving fine-scale measurements and computation of complex hydraulic variables have supported the flow-refuge concept by showing that mussel beds occur in patches where substrate remains

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Freshwater Science. 2016. 35(4):000–000. © 2016 by The Society for Freshwater Science.

Also…

R. Smit's 2014 MS Thesis; Auburn Univ.

"Using sonar habitat mapping and GIS analyses to identify freshwater mussel habitat and estimate population size of a federally endangered freshwater mussel species, Amblema neislerii, in the Apalachicola River, FL"